Le Châtelier's Principle

Problem

A 1.00 mol sample of $N_2O_4(g)$ is placed in a 10.0 L vessel and allowed to reach equilibrium according to the equation:

$2NO_2(g) \rightleftharpoons N_2O_4(g)$

Calculate the equilibrium concentrations of: $N_2O_4(g)$ and $NO_2(g)$.

$K_c = 4.00 \times 10^{-4}$ at 25° C

Now calculate the equilibrium concentration if instead you had 1.00 mol of NO_2 and no N_2O_4.

Le Châtelier's Principle

- ~whenever stress is applied to a system at equilibrium, a new equilibrium will be obtained to relieve this stress.
- This will "shift" the equilibrium to the right or left.

Le Châtelier's Principle

- A stress is a change in temperature, pressure, or concentration of some component.
- This will change the rate of reaction of either the forward or backward reaction
- So you will see an increase in the concentration of the substances on one side of the equation, and a decrease on the other.

Effects of Changes on the System

1. Concentration: The system will shift away from the added component. If a component is removed, the opposite effect occurs.
2. Temperature: *K* will change depending upon the temperature (endothermic – treat heat energy like a reactant; exothermic – treat heat energy like a product).

Redo Problem

What happens if we heat or cool our earlier problem? The K changes because the equilibrium concentration with change. Still start with .10 M N_2O_4.

$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$

Calculate the equilibrium concentrations of: $N_2O_4(g)$ and $NO_2(g)$.

$K_c = 2.9 \times 10^{-5}$ at 100° C

$K_c = 2.6 \times 10^{-2}$ at 0° C

$K_c = 570$ at -75° C

Effects of Pressure Changes on the System

3. Pressure:
   a) The system will shift away from the added gaseous component. If a component is removed, the opposite effect occurs.
   b) Addition of inert gas does not affect the equilibrium position.
   c) Decreasing the volume shifts the equilibrium toward the side with fewer moles of gas.

Problem

- In a study of the chemistry of glass etching, an inorganic chemist examines the reaction between sand (SiO_2) and hydrogen fluoride at high temperature:
- $SiO_2(s) + 4HF(g) \rightleftharpoons SiF_4(g) + 2H_2O(g)$
- Predict the effect on [SiF_4] when
- a) $H_2O(g)$ is removed
- b) some water is added at 220° C
- c) some HF is removed
- d) some sand is removed.

More

- How would you change the pressure (via a change in volume) of the following reaction mixtures to decrease the yield of products?
- $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$
- $CaC_2O_4(s) \rightleftharpoons CaCO_3(s) + CO(g)$
- $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

Last one

- How would a decrease in temperature affect the partial pressure of the underlined substance and K_p for the following reactions?
- C(graphite) + $2H_2(g) \rightleftharpoons \underline{CH_4}(g)$ + Heat
- $\Delta H = -75$ kJ →

Heat +

- $N_2(g) + O_2(g) \rightleftharpoons \underline{2NO}(g)$
- $\Delta H = 181$ kJ ←

- $P_4(s) + \underline{10Cl_2}(g) \rightleftharpoons 4PCl_5(g)$ + Heat
- $\Delta H = -1528$ kJ →